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Lee

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(54) **ELECTRONIC BALLAST THAT IS CONTROLLED BY THE OPERATION OF A SHARED SWITCH**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/483,915**

(22) Filed: **Jan. 17, 2000**

(30) **Foreign Application Priority Data**

Jan. 21, 1999 (KR) 99-1784

(51) **Int. Cl.**^{7} **H05B 37/00**

(52) **U.S. Cl.** .... **315/224**; 315/209 R; 315/247

(58) **Field of Search** .... 315/247, 224, 315/209 R, 244

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,936,357 * 8/1999 Crouse et al. 315/247

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Primary Examiner—David Vu

(74) *Attorney, Agent, or Firm*—Blakely Sokoloff Taylor & Zafman

(57) **ABSTRACT**

Disclosed is an electronic ballast that comprises a rectifier receiving and rectifying the alternating current (AC) power and outputting a result; a first converter receiving the output current of the rectifier and changing levels of the voltage by the on and off operations of a first switch and outputting the result; a half bridge converter coupled to the first converter in parallel and comprising a first and second switches shared with the first converter, and receiving the output current of the first converter and changing the directions of the current flow according to the status of the first and second switches by the on and off operations of the second switch; and a resonance circuit, coupled to the half bridge converter, resonating the output current of the half bridge converter and converting the current into sine wave current and outputting the current to a discharge lamp. The ballast according to the present invention decreases production costs and increases the efficiency of energy transfer.

12 Claims, 4 Drawing Sheets

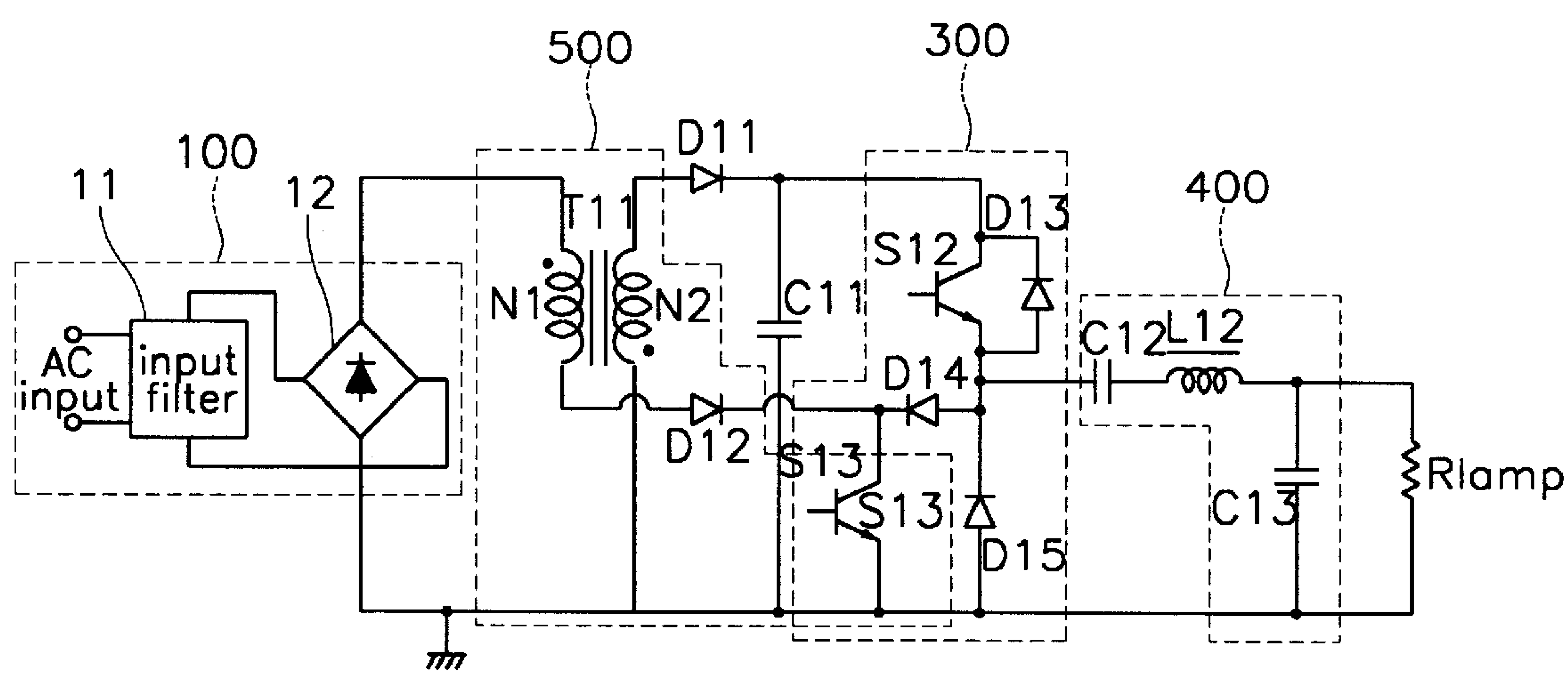
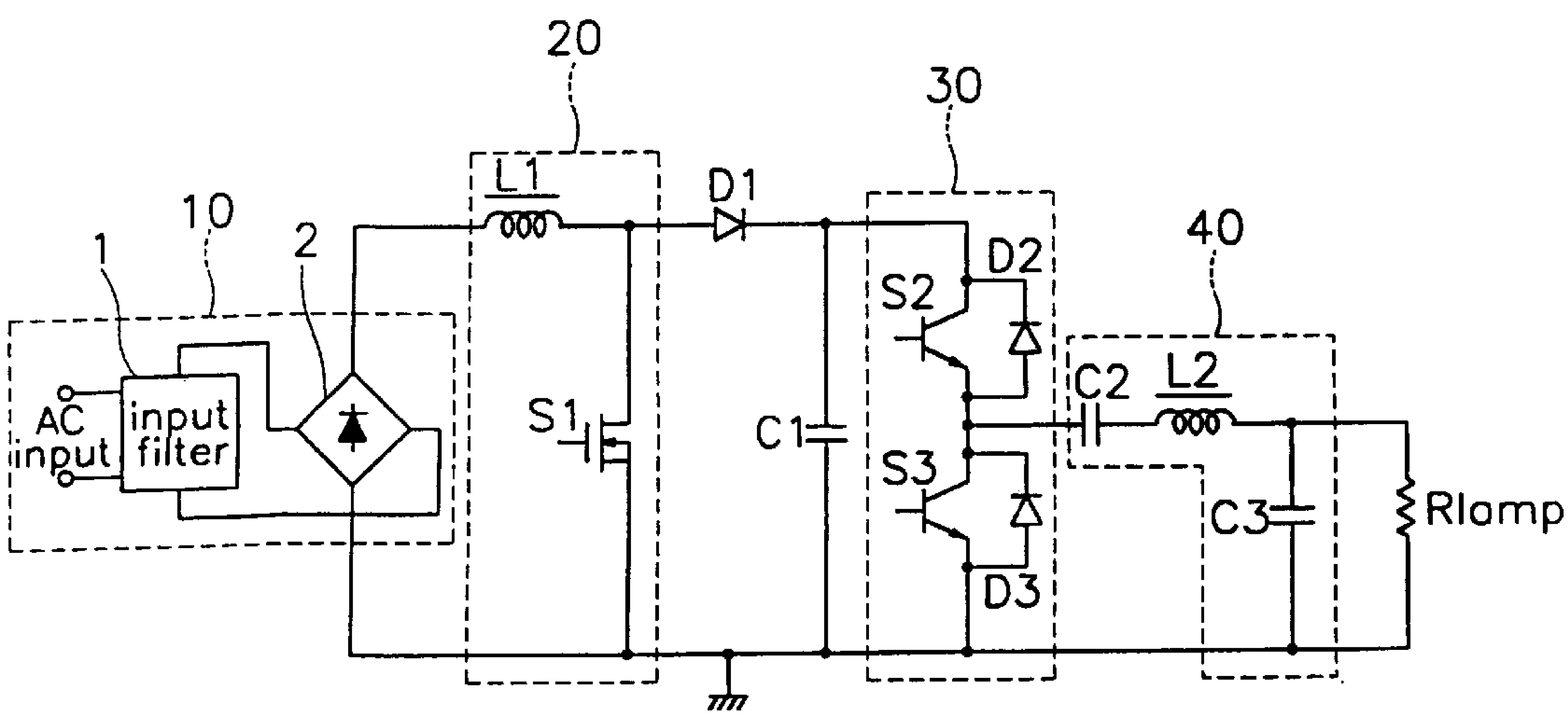
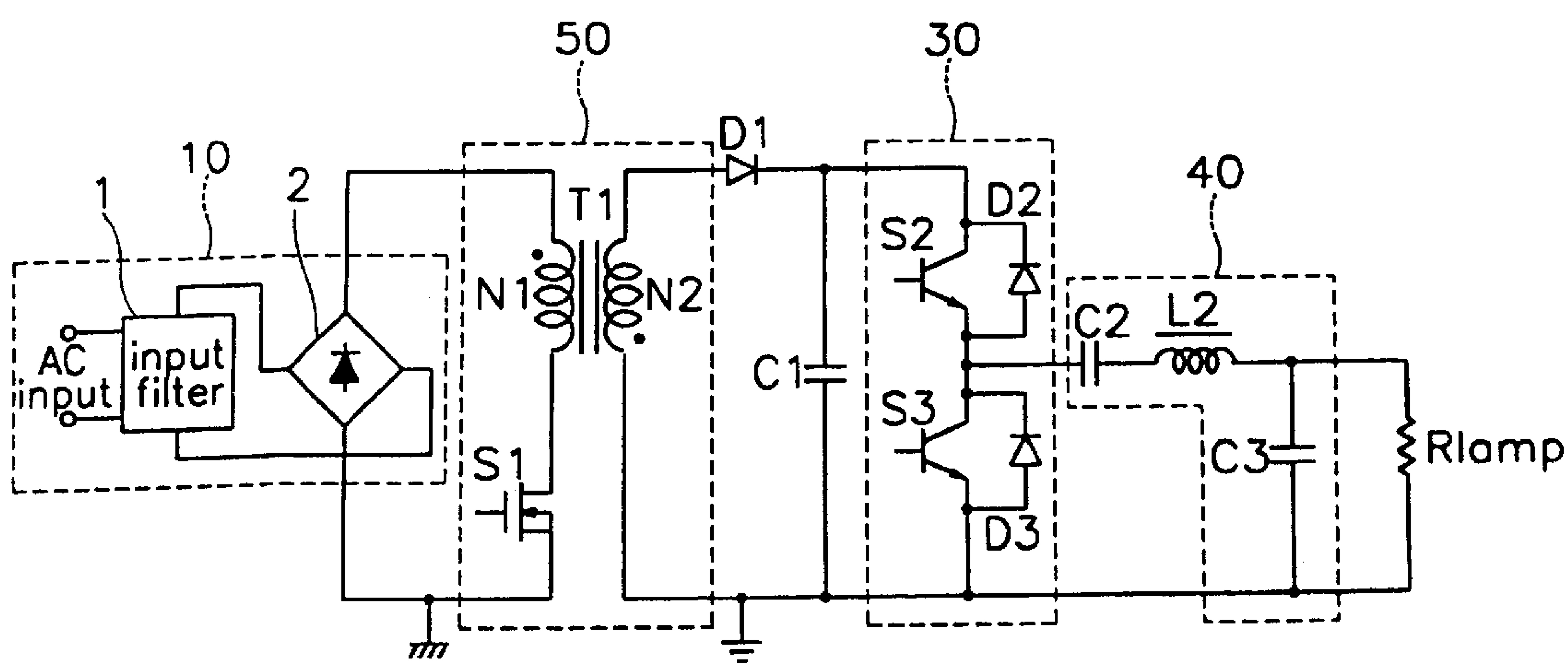


FIG.1



(PRIOR ART)

FIG.2



(PRIOR ART)

FIG.3

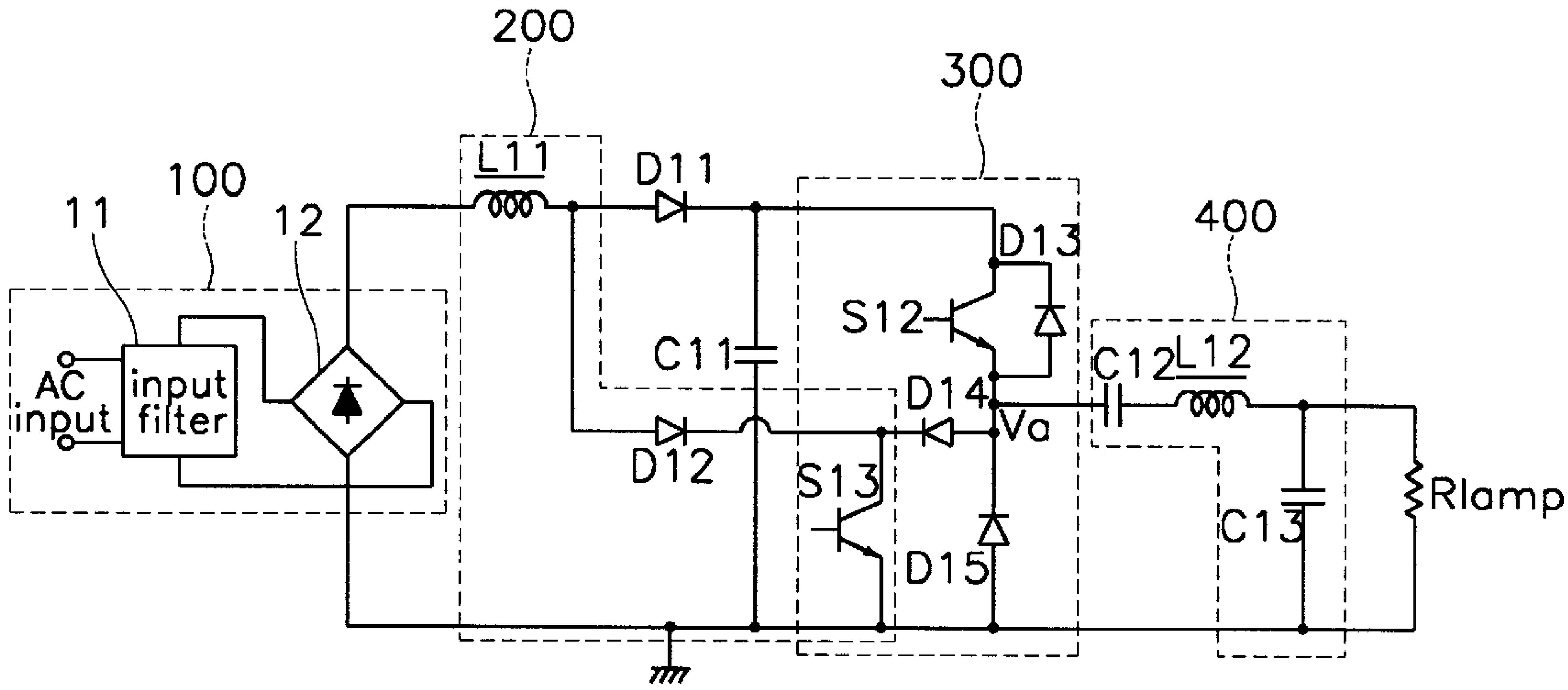
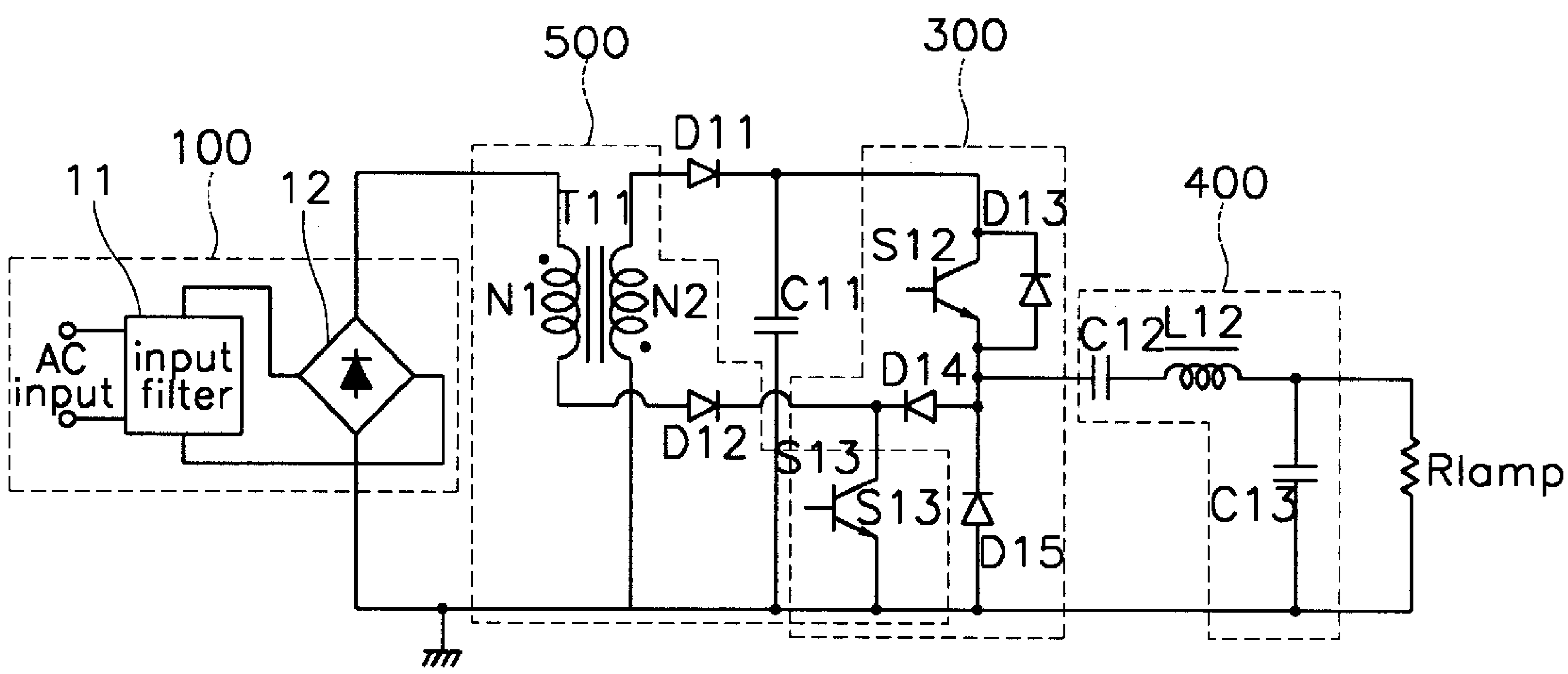

200
300
100
11
12
400
L11
D11
D13
S12
C11
C12
L12
AC input
input filter
D14
Va
D12
S13
Rlamp
C13
D15

FIG.4


500
300
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D11
T11
D13
S12
N1
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C11
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input filter
D14
D12
S13
S13
Rlamp
C13
D15

FIG.5A

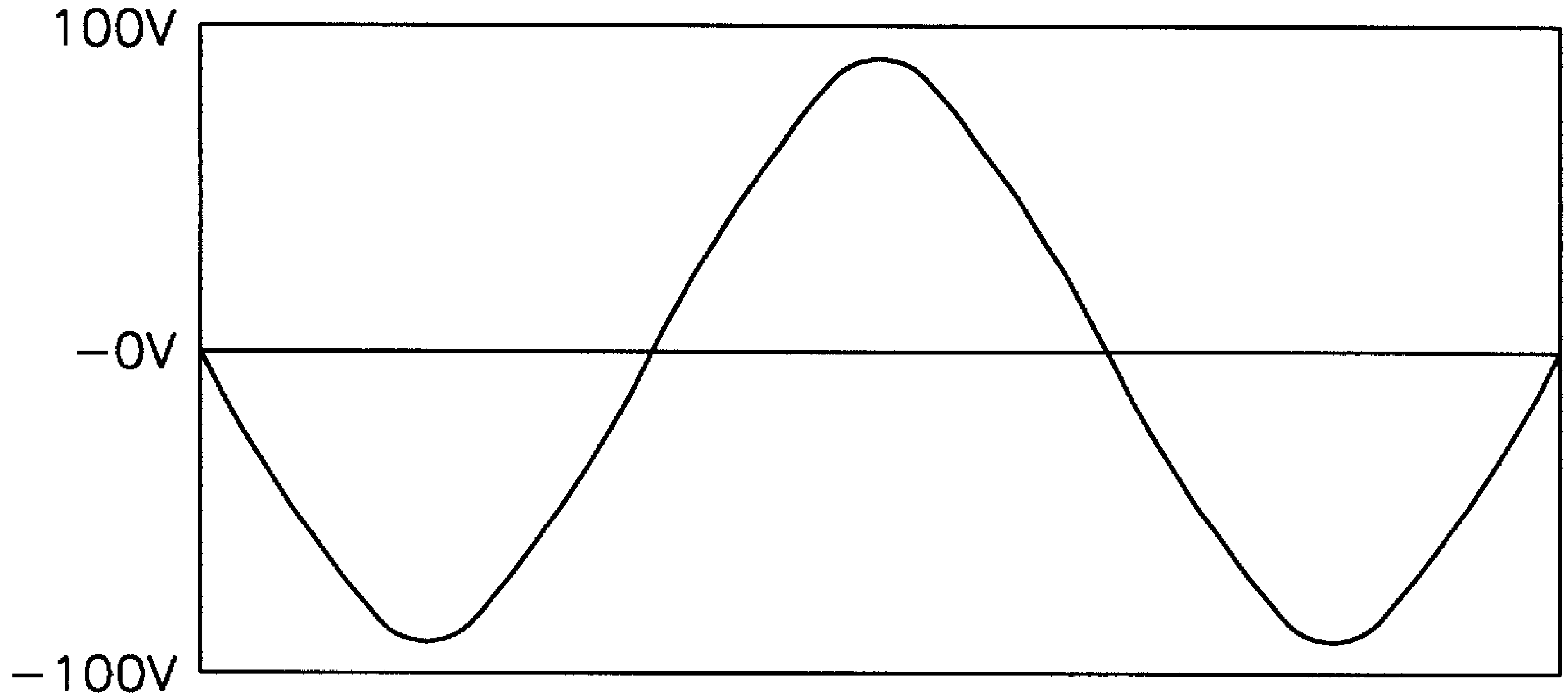


FIG.5B

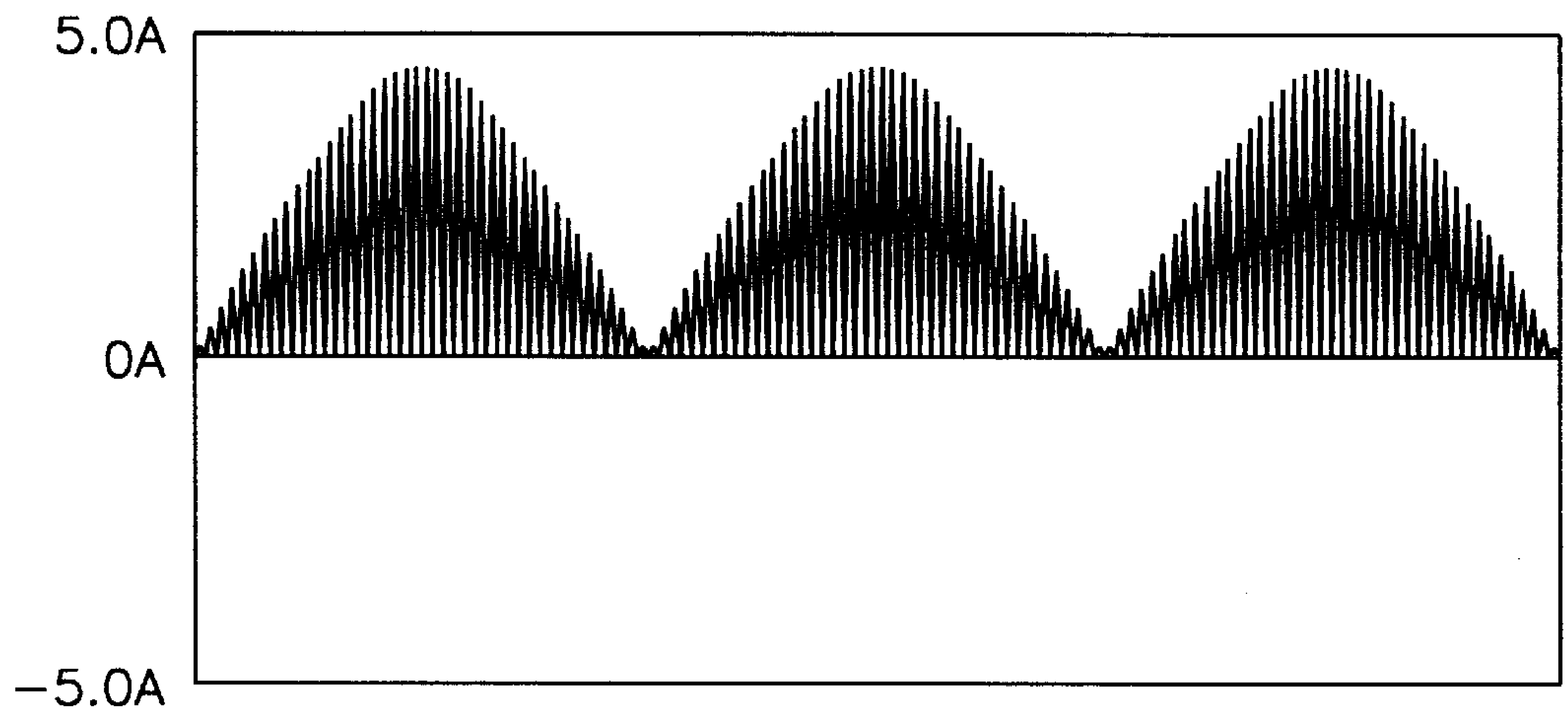
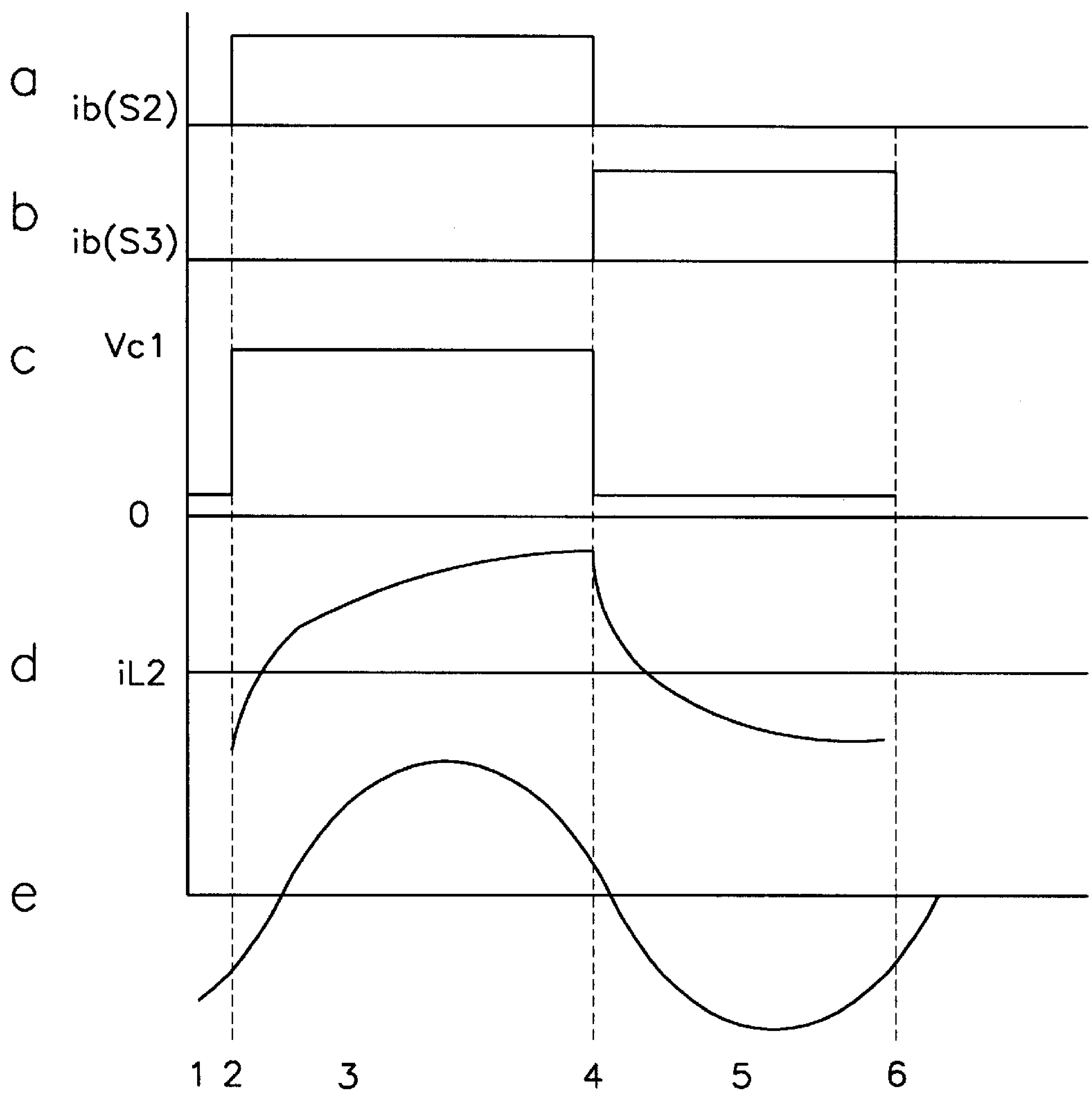


FIG.6



ELECTRONIC BALLAST THAT IS CONTROLLED BY THE OPERATION OF A SHARED SWITCH

BACKGROUND OF THE INVENTION

(a) Field of the Invention

The present invention relates to an electronic ballast. More specifically, the present invention relates to an electronic ballast that has a small number of components and a high degree of efficiency.

(b) Description of the Related Art

An electronic ballast provides stable power to lighting apparatuses such as fluorescent lamps and discharge tubes.

Since the fluorescent lamp and discharge tube emit light via a discharge process, the polarity of the supplied power must be switched at predetermined periods. To supply such power, the electronic ballast is implemented with a converter. Typically, a boost converter, half bridge converter, and flyback converter are used.

A conventional electronic ballast will now be described with reference to the drawings.

Referring to FIG. **1**, the conventional electronic ballast using the boost converter and half bridge converter comprises a rectifier **10**, a boost converter **20**, a diode D**1**, a capacitor C**1**, a half bridge converter **30**, a resonance circuit **40**, and a lamp Rlamp.

The rectifier **10** receives, rectifies, and outputs an alternating current (AC).

The boost converter **20** comprises a coil L**1** and a switch S**1**, and receives the rectified power to boost the power to a predetermined level, after which the boost converter **200** outputs the result.

One end of the diode D**1** is coupled to the coil L**1** and the switch S**1** and its other end is coupled to one end of the capacitor C**1**, the other end of the capacitor C**1** being grounded. The diode D**1** and capacitor C**1** smooth the output of the boost converter **20**.

The half bridge converter **30** is coupled to both ends of the capacitor C**1** and comprises two switches S**2** and S**3**. The half bridge converter **30** changes the polarities of the power by performing the switching operation on the voltage at the capacitor C**1** at a predetermined period, and outputs the result so that AC power is supplied to the discharge tube.

The resonance circuit **40** comprises capacitors C**2** and C**3** and a coil L**2**, and resonates the output power of the half bridge converter **30** to convert the output power to AC power having a predetermined frequency. After this conversion, the resonance circuit **40** supplies the AC power to the lamp Rlamp.

As shown in FIG. **2**, the electronic ballast using the conventional flyback converter and half bridge converter comprises a rectifier **10**, a flyback converter **50**, a diode D**1**, a capacitor C**1**, a half bridge converter **30**, a resonance circuit **40**, and a lamp Rlamp.

The flyback converter **50**, by the on and off operation of a switch S**1**, receives an output power of the rectifier **10** from a primary coil of a transformer T**1**, performs conversion of the power, then transmits the result to a secondary coil of the transformer T**1**.

In the above-noted conventional electronic ballast, a system having a boost converter connected to a half bridge converter, and another system having a flyback converter connected to a half bridge converter are described. The overall performance of such systems decreases as a result of these inefficient interconnections. Also, since the elements are physically coupled, the size of the circuit increases with an increase in the number of components, and overall reliability decreases. Manufacturing costs also go up with such configurations.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an electronic ballast that has a small number of components and obtains a high level of performance.

In one aspect of the present invention, an electronic ballast comprises a a rectifier receiving and rectifying an alternating current (AC) power and outputting a resulting output current; a first converter receiving the output current of the rectifier and changing levels of the voltage by the on and off operations of a first switch and outputting a resulting output current; a half bridge converter coupled to the first converter in parallel and comprising first and second switches shared with the first converter, the half bridge converter receiving the output current of the first converter and changing a flow direction of the current according to on and off states of the first and second switches; and a resonance circuit, coupled to the half bridge converter, resonating an output current of the half bridge converter to convert the current into a sine wave current and outputting the current to a discharge lamp.

The electronic ballast further comprises a first diode that is coupled between the first converter and the half bridge converter in the forward direction of the half bridge converter and prevents reverse flow from the half bridge converter to the first converter; and a first capacitor that is coupled to the first diode, the half bridge converter, and the ground, and smoothes and maintains the output current of the first converter.

The first converter is a boost converter or a flyback converter.

The second switch of the half bridge converter is coupled to the first capacitor, first diode, and first switch, and shares the first switch with the first converter, the first and second switches performing opposite on and off operations such that when the first switch is controlled to on the second switch is controlled to off and vice versa.

The resonance circuit comprises a second capacitor coupled to the first and second switches; a second inductor coupled to the second capacitor; and a third capacitor coupled between the second inductor and the ground.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention, and, together with the description, serve to explain the principles of the invention:

FIG. **1** is a circuit diagram of a conventional electronic ballast using a boost converter and half bridge converter;

FIG. **2** is a circuit diagram of a conventional electronic ballast using a flyback converter and half bridge converter;

FIG. **3** is a circuit diagram of an electronic ballast according to a first preferred embodiment of the present invention;

FIG. **4** is a circuit diagram of an electronic ballast according to a second preferred embodiment of the present invention;

FIGS. **5**A and **5**B are waveform diagrams diagram of an operation of a boost converter according to the first preferred embodiment of the present invention; and

FIG. **6** is a waveform diagram of an operation of a half bridge converter according to the first preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following detailed description, only the preferred embodiment of the invention has been shown and described, simply by way of illustration of the best mode contemplated by the inventor(s) of carrying out the invention. As will be realized, the invention is capable of modification in various obvious respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not restrictive.

FIG. **3** is a circuit diagram of an electronic ballast according to a first preferred embodiment of the present invention.

The electronic ballast comprises a rectifier **100**, a boost converter **200**, a diode D**11**, a capacitor C**11**, a half bridge converter **300**, and a resonance circuit **400**.

The rectifier **100** comprises a low pass filter **11** and a bridge diode **12**. The low pass filter **11** is coupled to an AC current input terminal, and the bridge diode **12** is coupled to both ends of the low pass filter **11**.

The boost converter **200** comprises an inductor L**11**, a diode D**12**, and a transistor S**13**, the transistor S**13** functioning as a switch. One end of the inductor L**11** is coupled to one end of the bridge diode **12**, an anode of the diode D**12** is coupled to the other end of the inductor L**11**, a collector of the transistor S**13** is coupled to a cathode of the diode D**12**, and an emitter of the transistor S**13** is grounded.

An anode of the diode D**11** is coupled to the inductor L**11** and the diode D**12**, one end of the capacitor C**11** is coupled to a cathode of the diode D**11**, and the other end of the capacitor C**11** is grounded.

The half bridge converter **300** comprises a transistor S**12**, which functions as a switch, and diodes D**14** and D**15**. A collector of the transistor S**12** is coupled to the diode D**11** and the capacitor C**11**, an anode of the diode D**13** is coupled to an emitter of the transistor S**12**, and a cathode of the diode D**13** is coupled to a collector of the transistor S**12**. Further, an anode of the diode D**14** is coupled to an emitter of the transistor S**12**, the collector of the transistor S**13** is coupled to a cathode of the diode D**14**, a cathode of the diode D**15** is coupled to the anode of the diode D**14**, and an anode of the diode D**15** is grounded.

The resonance circuit **400** comprises capacitors C**12** and C**13** and an inductor L**12**. One end of the capacitor C**12** is coupled to the transistor S**12** and the diodes D**14** and D**15**, one end of the inductor L**12** is coupled to the other end of the capacitor C**12**, one end of the capacitor C**13** is coupled to the other end of the inductor L**12**, the other end of the capacitor C**13** is grounded, and both ends of the capacitor C**13** are coupled to the lamp Rlamp.

An operation of the electronic ballast according to the first preferred embodiment of the present invention will now be described referring to drawings.

FIG. **5** is a waveform diagram of an operation of the boost converter according to the first preferred embodiment of the present invention, and FIG. **6** is a waveform diagram of an operation of the half bridge converter according to the first preferred embodiment of the present invention. When the AC power is supplied to the low pass filter **11**, the low pass filter **11** filters radio frequency (RF) components from the AC power before outputting the AC power as filtered output.

The bridge diode **12** then rectifies the filtered output of the low pass filter **11**. The output current of the bridge diode **12** is supplied to the inductor L **1**.

FIG. **5**(*a*) is a waveform diagram of the AC power initially input to the low pass filter **11**, and FIG. **5**(*b*) is a waveform diagram of the current flowing to the inductor L**11** via the diode **12**.

The output current of the bridge diode **12** is stored in the inductor L**11** in the form of electric energy when the transistor S**13** is turned on. When the transistor S**13** is turned off, the energy stored in the inductor L**11** is sent to the half bridge converter **300**. The current supplied from the inductor L**11** is supplied to the capacitor C**11**, and the capacitor C**11** smoothes the current supplied to the inductor L**11** and charges the inductor L**11**.

The diode D**12** prevents the current of the half bridge converter **300** from flowing to the boost converter **200**, and the diode D**14** prevents the current of the boost converter **200** from flowing to the half bridge converter **300**.

The operation of the half bridge converter **300** will now be described.

The two transistors S**12** and S**13**, respectively of the half bridge converter **300** and the boost converter **200**, perform opposite on and off operations so that a voltage of near square-wave form is supplied to the capacitor C**12**, the capacitor C**12** forming a resonance circuit.

That is, when the transistor S**12** is on, the transistor S**13** is off, and when the transistor S**12** is off, the transistor S**13** is on. If the transistor S**12** is turned on, the energy stored in the capacitor C**11** is transmitted to the resonance circuit **400** via the transistor S**12**, and if the transistor S**13** is turned on, the direction of the current flowing to the inductor L**12** of the resonance circuit **400** changes to a direction opposite that when the transistor S**12** is turned on.

The current supplied from the half bridge converter **300** is resonated by the resonance circuit **400** and is converted to AC current.

A voltage Vlamp measured by a current iL**12** flowing to the inductor L**12** and an equivalent resistance of the lamp Rlamp is shown by d and e of FIG. **6**.

As a result, the voltage having a waveform of e of FIG. **6** is supplied to the discharge tube lamp.

In the preferred embodiment of the present invention, the conventional method of using a separate switch for each the boost converter **200** and half bridge converter **300** is replaced by the on and off switching operation of the half bridge converter **300**.

This is made possible for the reason as follows. When the upper switch of the half bridge converter **300** is turned on and the lower switch is turned off, the energy stored in the capacitor C**11** is transferred to the half bridge converter **300**, and when the lower switch of the half bridge converter **300** is turned on and the upper switch is turned off, the capacitor C**11** is charged by the diode D**11**, and concurrently, the current is supplied by the diode D**12** and transistor S**13**. On the other hand, when the switch of the boost converter **200** is turned on, the current is not supplied to the half bridge converter **300**, but when the switch of the boost converter **200** is turned off, the current is supplied to the half bridge converter **300**. Therefore, if a switch duty ratio of the boost converter **200** is limited to below **50**%, when the switch of the boost converter **200** and the switch of the half bridge converter **300** are shared, no problems are encountered in the operation of the converters **200** and **300**.

Hence, an electronic ballast can be implemented which comprises a system that shares the lower switch of the half bridge converter **300**, and the transistor S**13** of the boost converter and is controlled by the operation of the shared switch.

FIG. **4** is a circuit diagram of an electronic ballast according to a second preferred embodiment of the present invention.

The electronic ballast comprises a rectifier **100**, a flyback converter **500**, a diode D**11**, a capacitor C**11**, a half bridge converter **300**, and a resonance circuit **400**.

The rectifier **100** comprises a low pass filter **11** and a bridge diode **12**. The low pass filter **11** is coupled to an AC current input terminal, and the bridge diode **12** is coupled to both ends of the low pass filter **11**.

The flyback converter **500** comprises a transformer T**11**, a diode D**12**, and a transistor S**13**. A primary coil of the transformer T**11** is coupled to one end of the bridge diode **12**, and an anode of the diode D**12** is coupled to a secondary coil of the transformer T**11**. Also, a collector of the transistor S**13** is coupled to a cathode of the diode D**12**, and an emitter of the transistor S**13** is grounded.

An anode of the diode D**11** is coupled to the secondary coil of the transformer T**11**, and one end of the capacitor C**11** is coupled to a cathode of the diode D**11** and its other end is grounded. The half bridge converter **300** comprises a transistor S**12** and diodes D**13**, D**14**, and D**15**. A collector of the transistor S**12** is coupled to the diode D**11** and capacitor C**11**, an anode of the diode D**13** is coupled to an emitter of the transistor S**12**, and a cathode of the diode D**13** is coupled to the collector of the transistor S**12**. An anode of the diode D**14** is coupled to the emitter of the transistor S**12**, the collector of the transistor S**13** is coupled to a cathode of the diode D**14**, a cathode of the diode D**15** is coupled to the anode of the diode D**14**, and an anode of the diode D**15** is grounded.

The resonance circuit **400** comprises capacitors C**12** and C**13** and an inductor L**12**. One end of the capacitor C**12** is coupled to the transistor S**12** and diodes D**14** and D**15**, one end of the inductor L**12** is coupled to the other end of the capacitor C**12**, one end of the capacitor C**13** is coupled to the other end of the inductor L**12**, the other end of the capacitor C**13** is grounded, and a lamp Rlamp is coupled to the capacitor C**13**.

An operation of the electronic ballast according to the second preferred embodiment of the present invention will now be described referring to drawings.

When the AC power is input to the low pass filter **11**, RF components of the sine wave AC power is filtered and output, and the bridge diode **12** rectifies the filtered output of the low pass filter **11**.

FIG. **5**(*b*) is a waveform diagram of the current rectified by the bridge diode **12** of the first preferred embodiment of the present invention. This current is provided to the primary coil of the transformer T**11**. When the switch S**13** is turned on, the current provided from the bridge diode **12** is stored in the primary coil, and when the switch S**13** is turned off, the current stored in the primary coil is transmitted to the secondary coil.

The current provided to the secondary coil is stored in the capacitor C**11**, and subsequent operations are identical with that of the first preferred embodiment of the present invention. The switch can also be shared to have effects identical to the first preferred embodiment of the present invention.

While this invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. An electronic ballast, comprising:

a rectifier receiving and rectifying an alternating current (AC) power and outputting a resulting output current;

a first converter receiving the output current of the rectifier and changing levels of the voltage by the on and off operations of a first switch and outputting a resulting output current;

a half bridge converter coupled to the first converter in parallel and comprising first and second switches wherein the first switch is being shared with the first converter, the half bridge converter receiving the output current of the first converter and changing a flow direction of the current according to on and off states of the first and second switches; and

a resonance circuit, coupled to the half bridge converter, resonating an output current of the half bridge converter to convert the current into a sine wave current and outputting the current to a discharge lamp.

2. The ballast of claim **1**, wherein the first and second switches are transistors that receive control signals through bases to perform the on and off operations.

3. The ballast of claim **1**, wherein the electronic ballast further comprises a first diode that is coupled between the first converter and the half bridge converter in the forward direction of the half bridge converter and prevents reverse flow from the half bridge converter to the first converter; and a first capacitor that is coupled to the first diode, the half bridge converter, and the ground, and smoothes and maintains the output current of the first converter.

4. The ballast of claim **1**, wherein the first converter is a boost converter.

5. The ballast of claim **4**, wherein the boost converter comprises a first inductor coupled between an output terminal of the rectifier and an anode of a first diode, and wherein the first switch is coupled between the first inductor and the ground.

6. The ballast of claim **5**, wherein the boost converter further comprises a second diode, an anode of which is coupled to the first inductor and a cathode of which is coupled to the first switch to prevent the flow of current from the half bridge converter.

7. The ballast of claim **1**, wherein the first converter is a flyback converter.

8. The ballast of claim **7**, wherein the flyback converter comprises a transformer that is coupled to the rectifier and receives the output current of the rectifier at a primary coil of the transformer and transfers energy to a secondary coil of the transformer with different voltage magnitudes, and wherein the first switch is coupled between the primary coil of the transformer and the ground and controls the transfer of energy to the secondary coil of the transformer by its on and off operations.

9. The ballast of claim **8**, wherein the flyback converter further comprises a diode, an anode of which is coupled to the primary coil of the transformer and a cathode of which is coupled to the first switch to prevent the reverse flow of the current of the half bridge converter.

10. The ballast of claim **1**, wherein the second switch of the half bridge converter is coupled to a first capacitor and a first diode, the first and second switches performing opposite on and off operating such that when the first switch is controlled to on the second switch is controlled to off and vice versa.

11. The ballast of claim **10**, wherein the half bridge converter further comprises a diode, a cathode of which is coupled to the first switch and an anode of which is coupled to the second switch to prevent the flow of current from the first converter.

12. The ballast of claim **1**, wherein the resonance circuit comprises a first capacitor coupled to the first and second switches; an inductor coupled to the first capacitor; and a third capacitor coupled between an inductor and the ground.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,225,753 B1
DATED : May 1, 2001
INVENTOR(S) : Lee

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page,
Item [75], Inventor, please delete "Bucheon" and insert -- Bucheon City --.

Column 2,
Line 65, please delete "waveform diagrams diagram" and insert -- waveform diagrams --.

Column 8,
Line 7, please replace "third capacitor" with -- second capacitor --.

Signed and Sealed this

Eighteenth Day of December, 2001

Attest:

JAMES E. ROGAN

Attesting Officer *Director of the United States Patent and Trademark Office*